PRELIMINARY ENERGY AUDIT

AT

TATA REFRACTORIES LIMITED
BELPAHAR, ORISSA

REPORT

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SUMMARY

An energy audit team from the Tata Energy Research Institute conducted a preliminary energy audit at the Belpahar plant of Tata Refractories Limited.

During the two-day visit to the plant, some critical measurements were made using instruments such as digital temperature indicator, portable combustion optimizer, lux meter and power multimeter.

The following is the summary of major recommendations of the energy audit team:

Summary and Recommendations

Item/Equipment/ System	Recommendation	Estimated Annual Savings*
Managing Energy Management Programme	Appoint energy manager/ energy coordinator	-
	Display energy conservation messages by means of signboards, posters and stickers	
Monitoring and data analysis	Install instruments at various locations to collect information on energy flow	-
	Perform comprehensive data analysis; set targets on energy conservation	-
Tunnel kilns		
- HTK	Ensure minimum heat loss so that higher temperatures in the firing zone could be achieved	1-2 %
- Kiln cars	Redesign tunnel kiln cars and provide low thermal mass bricks/refractories and ceramic fibre for insulation	~ 6 % (~ Rs. 4,60,000 for BTK only)
	Install automatic control systems on kilns	3-5 %

Summary and Recommendations (contd.)

Item/Equipment/ System	Recommendation	Estimated Annual Savings
	Investigate if waste heat in tunnel kilns exhaust could be recovered and utilized by installing heat pipe heat exchangers	Approx. Rs.1,50,000 per kiln
Driers	Construct driers with proper insulating materials. Ensure leak-tightness of doors	Overall: 15 per cent (Rs.6,00,000 on BTK alone)
	Ensure leak-tightness of doors	
	Install a temperature indicator on each drier	
Producer Gas	Prevent gas leak as far as possible	5 %
DG Sets	Improve efficiency of power generation	-
Air compressors	Locate suction lines away from compressors, to draw air at ambient conditions	1-2 %
Insulation	Insulate all hot bare surfaces.	2-3 %
	Upgrade insulation material and methods	
Motors	Use soft starters where motors could be loaded 50 per cent for sufficiently long periods.	8 % overall
	Investigate if motors could be replaced with energy-efficient motors.	
	Consider possibility of using slip-ring motor in place of a 55-kW grinder motor.	
	Load grinders to the maximum extent.	

Summary and Recommendations (contd.)

Item/Equipment/ System	Recommendation	Estimated Annual Savings*
Transmission drive pulleys	Use flat belts in place of V-belts where feasible	~ 7 %
Power factor	Install capacitors at load centres (e.g., a motor)	
Lighting	Consider using mirror-optic luminaires	~ 10 % overall
	Replace 20-W lamps with 36-W FL lamps	
	Replace mercury-vapour lamps with sodium vapour lamps	
	Consider installing Beblec P-20 devices	
	Use low-pressure sodium-vapour lamps for outdoor lighting	
Plant	Conduct a detailed energy audit	

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* Estimated annual energy savings are for the corresponding equipment/system in the first column. The percentages are of the total energy consumed in the respective equipment/system.

INTRODUCTION

An energy audit team from the Tata Energy Research Institute, New Delhi conducted a preliminary energy audit at the Tata Refractories Limited, Belpahar, Orissa on March 19 and 20, 1990.

After an initial tour of the plant and its facilities, the energy audit team, consisting of M/s. G. Sambasivan and S. Anand, took measurements of various energy related parameters of many equipment/systems. The data collected during the site visits and from questionnaires was analyzed. Based on the results of data analyses, and observations made during the site visits, recommendations for improving energy efficiency of various pieces of equipment/systems were arrived at. These recommendations along with the results of data analyses are given in this report.

Since it was a preliminary energy audit, in most cases the investment required to implement energy conservation measures recommended in this report is not provided. However, energy savings in physical and monetary units have been given, wherever possible. If a detailed energy audit is required for certain pieces of equipment/systems, it has been mentioned in this report.

The energy audit team gratefully acknowledges the help provided during its plant visit by Mr. J. Pandey and Mr. J.P. Rupera, and a few other staff members of the Company.

Energy Consumption

At the Tata Refractories Limited, Belpahar, Orissa, the main products are fireclay bricks; basic, silica and high alumina refractories; monolithics; and ramming masses. The energy sources used are coal, furnace oil, H.S.D.O., and electricity. Coal is converted to producer gas (CO - 26 %, H_2 - 12 to 14 %, and N_2 - 52 %), which in turn is used in tunnel kilns and gas-ring kilns.

The major thermal energy consumption centers are kilns, and for electricity it is motors. Motors of various sizes are used in crushing and grinding mills, mixers, moulding machines, fans, blowers, compressors and pumps. Electricity is also consumed in lighting within and outside the plant, and in buildings.

In addition to purchased electricity, the plant uses electricity from DG sets which are operated during power breakdowns and powercuts. The plant consumed a total of 1,61,00,000 kWh of electricity during 1988-89. In the same period, the fuel consumption was: diesel oil - 1491 kL, furnace oil - 4815 kL and coal - 17842 tonnes(t).

The total cost of purchased energy in 1988-89 was approximately Rs. 6.23 crores. The energy cost as a share of the total manufacturing cost was approximately 15.9 per cent. Therefore, this plant could be termed as an energy-intensive, large energy consuming plant.

Table 1 provides the energy consumption data for the plant for 1985-86, 1986-87 and 1987-89 (prorated for 12 months).

In Table 1, the overall specific energy consumption values have been computed from the thermal energy input from fuels and the thermal energy equivalent of purchased electricity. It is observed that the specific electricity and energy consumption values increased or decreased as shown in the table below.

	Percentage increase/decrease between		
	1985-86 & 1986-87	1986-87 & 1987-88	1985-86 & 1987-88
Capacity utilization	(-)30.8	71.7	18.8
Specific electricity consumption	61.5	(-)44.4	(-)10.2
Specific energy consumption	(-)0.43	(-)19.0	(-)19.4

It is clear that the overall specific electricity consumption increased with decreasing capacity utilization and vice versa. However, for the period between 1985-86 and 1986-87, the overall specific energy consumption decreased slightly with decreasing capacity utilization. This may be explained by the product mix which would have been less energy intensive. Between the periods 1986-87 and 1987-88, and 1985-86 and 1987-88 (2 years), the overall specific energy consumption values have decreased with increasing capacity utilization, as would have been expected.

Table 1

Plant Energy Consumption Data and Analysis

Details	1985-86	1986-87	1987-88*
Installed capacity (t)			
- Fire bricks	56,000	56,000	56,000
- Basic bricks	47,000	47,000	47,000
- Silica bricks	20,000	20,000	20,000
- Total	1,23,000	1,23,000	1,23,000
Production (t)			
- Fire bricks	36,252(48.7)	22,533(43.7)**	30,782(34.8)
- Basic bricks	29,709(39.9)	22,952(44.5)	45,241(51.1)
- Silica bricks	8,496(11.4)	6,039(11.8)	12,441(14.1)
- Total	74,457	51,524	88,464
Overall capacity utilization (%)	60.5	41.9	71.9
Energy Consumption			
Coal (t)	19,498.48	11,352.21	17,841.68
Furnace oil (kL)	4,629.06	4,507.64	4,815.39
Diesel oil (kL)	1,679.16	265.83	1,491.21
Electricity (purchased) (kWh)	1,50,00,000	1,69,00,000	1,61,00,000
Electricity (self-generated) (kWh)	3,95,730	3,04,790	3,31,740
Specific electricity consumption(1) kWh/t	206.8	333.9	185.7
Specific energy consumption(1) Gcal/t	2.087	2.078	1.683
GJ/t	8.724	8.686	7.035

* Prorated for twelve months from 1987-89 data

** Numbers within brackets are percentage shares in total production.

(1) Calorific values

Furnace oil - 9,650 kcal/kg
Coal - 4,500 kcal/kg
Diesel oil - 10,200 kcal/kg
Electricity - 860 kcal/kWh

As regards electricity consumption, there is a fixed load irrespective of the production quantity[*]. It is important to reduce the fixed loads to the maximum extent possible to minimize the effect of capacity utilization on specific energy consumption. From the data for the years 1985-86 and 1986-87, it is apparent that the fixed load in the plant is significant (i.e., a large share of total electricity consumption is in the fixed load).

The above analysis illustrates an approximate method of calculating specific energy consumption values, and interpreting results. A more accurate method would be to determine these quantities for each type of product, viz., silica, fireclay and basic bricks, etc., and make a comparison. (See next chapter on Data and Analysis).

It is important to note that to reduce specific energy consumption values, the plant should be operated close to 100 per cent capacity.

DATA AND ANALYSIS

Table 2 presents electricity consumption data for three major products viz., basic refractories, fire bricks (from Old and New Plants) and silica refractories for March 17, 1990[**]. Electricity consumption in grinding, mixing and pressing, and the total consumption are given. From total production quantities of different products for each day, specific electricity consumption values for a given day is calculated as shown in the table.

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[*] Fixed load in the plant includes pumps, air compressors, heating, cooling and ventilation (HVAC), and lighting.

[**] (TRL collects energy (electricity) related data as shown below regularly, and performs simple analysis to determine specific energy consumption. The energy audit team noticed that some energy-related data was displayed in one area of the plant).

Table 2

Daily Electrical Energy Consumption

Date : March 17, 1990

Product Name	Production Quantity (t)	Electricity Consumption, kWh				Specific Electricity Consumption (kWh/t)
		Grinding	Mixing	Pressing	Total	
Basic refractories	144.67	2770	1460	2110	6340	43.82
Fire bricks (old plant)	44.66	850	1110	1090	3050	68.29
Firebricks (new plant)	37.19	1110	200	450	1760	47.32
Silica refractories	39.46	1950	400	1600	3950	100.1
Total	337.59	-	-	-	47620	141.05
Total till date	4292.47	-	-	-	789590	183.94

The format as shown in Table 2 is very useful in analyzing energy consumption pattern in any section of the plant. The following are the recommendations of the energy audit team as regards energy use data and its analysis:

a. Data for thermal energy (in terms of oil, coal/producer gas, etc.) should also be collected and analyzed.

b. In addition to the specific electricity/energy consumption based on the total consumption for each type of product, specific fuel/energy consumption values for each major step in the process should be computed, and results interpreted.

c. Specific energy consumption values can be affected due to weather conditions. Therefore, variations in the values of specific energy consumption and norms for different seasons in a year, if any, should be determined.

d. It is important to devise methods of interpreting the results of (energy-related) data analysis, and to take corrective action to rectify major deviations.

e. It is seen from Table 2, that firebricks from the new (expansion), plant consumes much less electricity per tonne of product than the ones made in the old plant. It should be explored, if the old plant could be operated to produce only the quantum needed to fill the gap between demand and supply from the new plant.

f. The type of analyses shown in the table should result in target setting, i.e., to reduce specific energy consumption for each of the products.

g. Suitable charts/graphs should be prepared to quickly analyze and display the results visually.

Comprehensive data analyses would require monitoring of energy consumption at various locations at the plant. Both static and portable instruments are needed to measure energy flows. At TRL, there should be a time-bound programme for providing sufficient instrumentation of reliable quality and accuracy.

MEASUREMENTS, ANALYSES, RESULTS AND RECOMMENDATIONS

In this chapter the data collected from the questionnaires, nameplates, design values, and measurements during the plant visit is given. The results of analyses and the interpretations of the same are presented. Based on observations of the energy audit team during its site visits and the results of data analyses, recommendations are given in this report.

Tunnel Kilns

The energy audit team studied the energy consumption pattern in tunnel kilns in the Old Basic Plant, viz., BTK, FTK - 1 & 2 and HTK. Most of the recommendations given in this section would be applicable to other kilns which are either operating or being built.

The design operating temperature of basic tunnel kiln (BTK) is approximately 1450°C, that of fire brick tunnel kilns (FTK-1&2) 1470°C and that of high temperature tunnel kiln (HTK) 1650°-1750°C. Due to certain problems, HTK was operating at a lower temperature of 1530°C on the day when measurements were taken. In the basic tunnel kiln, a new car is pushed in every 60-70 min., and it takes 72 hours for firing the bricks. All the kilns have (pre)heating, firing and cooling sections. The construction and operational methods of the kilns ensure final product quality, heat recovery from hot combustion gases, preheating/cooling of bricks, flame length and proper combustion of furnace oil and producer gas. Producer gas is used as a supplement to furnace oil essentially to save fuel oil and hence, on energy cost.

The energy audit team took measurements of surface temperatures at various points outside the kilns, at ancillary equipment, of products at the outlet and the outside surface temperature of hot air duct from BTK to dryers. The results, observations and recommendations are presented below :

Observation	**Recommendation**
The temperature of the firing zone of HTK was 1530°C, instead of 1650°-1750°C. This might be due to a combination of factors such as heat losses, excess quantity of air leading to dilution of combustion products and lower sizing of burners and inadequate number of burners.	Before making changes to burners or adding to the number, it is important to plug all preventable heat losses, and optimize the flow of cooling air and size of hot air duct. Even after ensuring the above, if there is still a problem in attaining the design temperature, changes/additions to burners should be investigated.
The exits of tunnel kilns were completely open. When the cars were not fully loaded, there was heat loss due to convection and radiation.	It should be investigated if insulating curtains can be provided at the exit of the kilns. Heat loss from warm air leaving the kilns, and the radiation heat loss from the flame at the midpoint could be prevented by suitably designed curtains (made of asbestos). It should, however, be ensured that these curtains do not slow down the cars.
The cars were insulated with heavy refractories leading to a large thermal mass. According to an estimate, 31 per cent of the heat input to the furnace goes to heat the cars. Out of this energy, 10 per cent is lost underneath the kiln car and 90 per cent is stored energy, which is proportional to its weight. In a typical kiln application, cars account for about half	As the thermal energy absorbed by the kiln cars represents the highest quantum of wasteful energy, it is important to reduce the thermal mass of the kilns. This can be done by switching over to lightweight refractories (e.g., low thermal mass (LTM) refractories/bricks), and ceramic fibre blankets and optimizing the kiln furniture and construction(one of the suppliers' name and address are given in Appendix I) It is suggested that the Central Glass Ceramic Research Institute at Calcutta may be contacted for details on work

the thermal load as compared to the ware they carry.	done in this area in our country. Approximately 6 per cent reduction in the fuel used in the kiln is possible through the use of lightweight construction materials (i.e., LTM bricks and ceramic fibre blankets) in the kiln cars. For example, in BTK, this would mean a saving of 0.36 KL of furnace oil per day or 131 KL per year (Rs.4,60,000 per year). Ceramic fibre lining over the walls, roofs, doors and kiln cars in both batch-operated and continuous kilns contribute to a large efficiency improvement. In some cases fuel savings of up to 22 per cent have been achieved. Next to the kiln lining, probably the biggest fuel saving measure in ceramic industry is the use of low thermal-mass kilns. Basically, thin, strong refractory posts and structure are designed to carry the weight of the car load. The basic contradictory requirements of designing kiln car lining are the mechanical strength to carry the heavy load and proper insulation. Normally, the area around the refractory support structure is filled with ceramic fibre lining to obtain maximum insulating value. By applying this design, the total mass of the refractories in kiln cars can be reduced to as small as 10-15 per cent of that of the original lining. Reduced heat storage (thermal mass) of the kiln car is directly proportional to the weight reduction in the kiln car. Hence, there is a reduction in fuel consumption in kilns. Application of ceramic fibres in kiln cars in one form or another has led to surprisingly better temperature uniformity throughout the kilns.
There is no automatic control of temperatures, air flow, oil flow, etc. in the kilns.	Total or partial automation of operation of the kiln should be considered, to begin with in one kiln. It is expected that 3-5 per cent

energy could be saved by total automation. In a totally automated tunnel kiln, temperature throughout the furnace zone can be controlled automatically by solid state micro-processor type instruments. These measure temperatures at various points within the kilns, adjusting flows of gas/oil to burners to maintain desired temperature levels.

On BTK, with a 6kL furnace oil consumption per day, a saving of 3 per cent would be 66 kL per year. (Rs. 2,31,000 per year).

Flue gas composition measured in both BTK and FTK-2 revealed high CO concentration. (See Table 3). This indicates that a part of fuel input to the kiln was unburnt. Though O_2 concentration in the exhaust of the firing zone could not be measured, it is assumed to be indicative of excess air being fed into the kiln for combustion. Under this condition a high CO concentration indicates problems with the burner assembly. The CO concentration in flue gas where there is good combustion would be less than 50 ppm. (The high velocity burners used in the tunnel kilns are inherently more energy efficient than conventional burners). The high O_2 concentration shown in Table 2 is due to air being pumped into the kilns other than for combustion alone.

Periodic cleaning and maintenance of burners is important to ensure proper nozzle alignment and hence, complete combustion of oil/gas.

Exhaust temperature measured at FTK-2 and BTK stacks were 243°C and 214°C respectively.

For small temperature gradients, heat pipe heat exchangers could be applied. The exhaust temperature after the heat pipe exchangers could be as low as

160°C, without any danger of sulphuric acid condensation in the stacks. These heat pipe heat exchangers should be installed close to the tunnel kilns. The heat recovered could be in the form of preheated air to the kilns.

If heat pipe heat exchangers are installed, it should be ensured that fouling of the fins on heat pipes is reduced by filtering the stack gases before the heat exchanger. The addition of filters and heat pipe heat exchanger might require a larger exhaust fan.

Table 3

Kilns

Flue Gas Measurements

Ambient temperature = 37°C

Location	Flue gas temperature (°C)	Flue gas composition O_2 (%)	Flue gas composition CO (ppm)
BTK, Exhaust 2	214	17.6	738
FTK-2 Exhaust 2	243	18.1	230

A detailed energy audit of all kilns in the plant should be conducted.

Driers

There is a series of driers for drying refractory bricks before they are fired in the kilns. The driers are heated directly by hot air from the tunnel kilns. The hot air from the kilns is pumped by blowers, into insulated ducts which are located above the ground level. A portion of the ducting made of brickwork runs below ground near the driers.

The following are the observations and recommendations of the energy audit team:

Observation	**Recommendation**
Driers are constructed with ordinary bricks and cement mortar. There is no insulating material used. Driers operate at temperatures between 60-80°C.	All driers should be constructed with proper insulation so that very little heat leaks out. In a phased manner, old driers should be replaced with new, well insulated driers (with firebricks, mineral wool, glass wool, etc.).
The doors on the driers are not lined nor are they leak-tight. As a result, large quantities of hot air leak out from driers. Moreover, on some driers the doors were totally open.	Doors on driers should be lined with asbestos rope, and they should be leak tight when closed. Operations staff should ensure that doors are properly closed before letting in hot air for drying.
Doors are not insulated	All dryer doors should be insulated with glass wool/rock wool.
Many valves/dampers on the duct (close to the dryers) are leaking.	All leaking valves/dampers should be repaired/replaced. For replacement, butterfly valves with metallic seats are recommended.
Ducting below ground level loses energy due to lack of insulation.	All ducts should be above ground level. Otherwise, proper insulation of ducting below ground level should be done. The latter would be more expensive then relocating ducting above ground.
There is no temperature control of driers.	Control of temperature in each drier by manual damper control should be done. (A temperature indicator on each drier should be installed.)
The ducts are insulated with glass wool and covered with black-coated jute cloth.	Normally, proper insulation is done with aluminium (sheets) cladding over glass or mineral wool. This prevents ingress of water into the insulation. (A moist insulation would be very ineffective). Moreover, polished aluminium has a low emissivity and hence, heat loss from the outer surface would be minimal. Investigate, if jute cloth cover on duct insulation could be replaced with aluminium sheet, after performing an economic analysis. For all new duct or pipe insulation, only aluminium cladding should be used.

Appendix II provides details on energy losses in the ducts/driers system associated with BTK. Conservatively a heat loss of 15 per cent (estimated) would translate to Rs. 6,03,000 per year.

A detailed energy audit of driers and associated hot air system should be conducted.

Producer Gas Unit

Producer gas is made from coal in five units within the plant. The net heating value of producer gas is approximately 1350 kcal/N cu.m. One kilogram of coal yields 3 cu.m of producer gas. Producer gas is used in tunnel kilns as supplementary fuel. As producer gas is cheaper than oil on calorific value basis, it is economical to use it in kilns.

The following are the observations and recommendations of the energy audit team :

Observation	**Recommendation**
Producer gas was leaking at various places in the plant. This is mainly at the valves. At a few place, the leak rate was estimated to be more than one cu.m. per min. (one thousand cu.m of producer gas is worth approximately Rs. 167). It is estimated that hundreds of cu.m of producer gas is leaking at the plant everyday. As CO content is high, leaking producer gas can be a health hazard.	Though, perfect leak tightness in the producer gas lines may be difficult to achieve, it is important to maintain all valves and accessories routinely.

A detailed energy audit of all producer gas units should be conducted.

Diesel Generating (DG) Sets

The total generating capacity in the plant is 1300 kW. On the days of the visit by the audit team, the DG sets were not operating. Table 4 presents energy-related data for DG sets supplied by Tata Refractories Limited, and the results of analysis.

Table 4

Captive Power Generation Using Diesel Generating Sets

Details	Year 1985-86	 1986-87	 1987-88
Installed generating capacity (kW)	1300	1300	1300
kVA	1655	1655	1655
Power factor (average)	0.9	0.9	0.9
Load factor	3.5	2.7	2.9
Total diesel oil consumed (kL)	1679.16	265.83	1491.21
Specific energy generation ratio (SEGR)(kWh/L)	0.236	1.147	0.2225
Typical attainable SEGR (kWh/L)*	3.4-3.8	3.4-3.8	3.4-3.8

* Typical SEGR attainable by well maintained diesel generating sets is based on the data provided in an extensive study on DG sets titled "A study in Alternative Generation Expansion Strategies for the Northern Region" conducted by TERI for the Advisory Board on Energy, Government of India.

From the above table, it is seen that :

a. The average load factor (capacity utilization) of DG sets has been very low. This indicates higher utilization of grid power. However, in the present power scenario, DG sets are a necessity.

b. The specific energy generation ratio is rather very low in every year in comparison with typical SEGR values attainable. It is suspected that the data on power generated and diesel oil consumption is not correct. However, if the data is correct, measures have to be taken to drastically improve the efficiency of DG sets.

Appendix III provides valuable tips on conserving diesel oil as well as lubricants.

Recommendation	**Observation**
Exhaust pipes of DG sets in the DG sets room were insulated with asbestos rope.	Though asbestos rope is an insulating material, it is not the appropriate one for pipes and ducts. Therefore, the exhaust pipes inside the room should be insulated with glass wool of sufficient thickness and covered with aluminium cladding.

Air Compressors

There are seven air compressors which are located in one area of the plant. Normally, four compressors are run during the day and three in the night. The following are the observations and recommendations for energy saving in air compressor operation.

Observation	**Recommendation**
A significant air leak was noticed.	As compressed air is an expensive input in the plant, it is important to prevent air leakages at various points. During plant maintenance, if compressed air is not used at all, it would be possible to find the air leak rate from the system by observing the initial pressure in the air receiver, time taken for the final pressure, pressure drop and approximate system volume. Corrective measures should be taken to seal all leakages after identifying them during plant maintenance or even during normal operating period.
The audit team learnt that workers used compressed air for body cooling purpose.	It is much cheaper to provide fans at a few more places than use compressed air for cooling. Moreover, the workers should be made aware of the significant electrical energy waste due to their use of compressed air for personal comfort.
Suction air temperature ranged from 1.4°-4.2°C higher than the ambient temperature just outside the building. The temperature readings taken at the suction points of some compressors are given Table 5.	When the suction air temperature is higher than the ambient temperature, compressor efficiency is affected. For every 3°C rise in temperature of inlet air, one per cent additional energy is required for the same mass output of compressed air. If the suction lines can be laid such that the air inlets are located outside the

building, the suction air would be close to ambient temperature, which would result in higher compressor energy efficiency. The extension pipes (suction lines) to outside the building should be of mild steel to ensure rigidity. The diameter of suction lines should be high enough to make sure of design flow rates of air. The inlet pipe to each compressor should be provided with a slope away from the compressor and a drain pipe to prevent water entering the compressor unit. The existing air filters could be used at the outdoor air intake, but it has to be protected from rain water.

The manufacturers should be contacted regarding the changes recommended above before any changes are made.

Table 5

Air compressors - Suction Air Temperatures

Date: March 19, 1990
Time: 15:55 h
Ambient temp.: 36.6°C

Compressor No.	Suction Air Temperature (°C)	Suction Air Temp. - Ambient Temperature (°C)	Drop in Compressor Efficiency (%)
KGK No. 2	40.8	4.2	1.4
KGK No. 3	38.0	1.4	0.5
KGK No. 4	38.6	2.0	0.7
KGK No. 5	39.6	3.0	1.0
OPT 1	40.3	3.7	1.2
OPT 2	40.6	4.0	1.3

Energy Saving

As an example, for compressor KGK No. 3 (100-kW motor), operating at full rated capacity and 50 per cent load factor, at a minimum of 0.5 per cent increase in energy efficiency, the annual energy saving potential by relocating the suction line would be approximately Rs. 2800/-. The cost of implementing the change can be worked out by plant personnel.

Heat Loss and Insulation

With the help of a digital temperature indicator, temperature measurements were taken at various locations of surfaces which were insulated or bare. The data was analyzed to determine the heat loss in monetary units per sq.m of surface exposed. The temperature data and the results of analysis are given in Table 6.

Table 6

Hot Surfaces

Location	Surface Temp. (°C)	Net Heat Loss (W/m^2)	Annual Energy Loss (Rs/m^2)
BTK			
Zone 21			
Point 1(Al-painted)	76.0	75	330
Point 2(Al-painted)	72.0	35	150
Zone 24	157.0	1,027	4,450
Zone 16			
Zone 26	209.0	2020	8,750
Zone 29			
Point 1	158.0	1159	5,020
Point 2	112.0	511	2,210
Point 1(Ins.)	42.0	20	90
Point 2(Ins.)	47.0	50	220
Air Blower			
Cylindrical surface	168.0	1820	7,900
Air Duct			
bare surface			
Point 1	117.0	802	3,500
Point 2	111.3	733	3,200
Duct to driers			
Ins.Surface(Jute)	42.3	86	375
Bare Surface(Nr.fan)	51.8	138	600
HTK			
Zone 18	99.0	317	1,370
Zone 16	80.0	115	500
Zone 17	78.9	104	450
Zone 19	79.5	110	480
Air Blower			
bare surface	92.0	245	1,060

* For Notes see Appendix IV

Observation	Recommendation
Most parts of BTK at the preheating and cooling zones were well insulated and painted with aluminium paint. However, there was significant heat loss near the burner blocks and areas around them. In contrast, HTK was better insulated near the firing zone.	It is important to insulate areas outside the firing zone well, so that heat loss is reduced to a minimum. Consider insulating the outer surface of firing zone with mineral wool of sufficient thickness.
The bare surface of air blowers were losing significant amount of energy.	All hot outer surfaces, where inside fluid is at a temperature of 60°C or above should be properly insulated.
Hot air ducts to driers were generally well insulated.	It is important to ensure that there are no bare surfaces including those of flanges on the ducts.

Detailed energy audits of individual pieces of equipment and systems should include insulation also.

Motors

Data Collected and Measurements

To evaluate the performance of motors, tests are conducted under no-load and load conditions; input parameters under these conditions, such as current, voltage, power input, power factor, speed and frequency are measured.

Measurements were made on a sample of nine motors under load conditions. Since decoupling a motor to conduct tests under no-load conditions would entail stopping the machine, measurements on no-load could not be made on four of the motors tested. The details of the motors tested are given in Table 7.

Table 7

Details of Motors Tested

S. No.	Motor Rating (kW)	Application
1.	11*	Water recirculation pump (No.1)
2.	30	Exhaust fan for kiln No.3
3.	45	Pump (No.1, pump house)
4.	55	Grinder No.3 (F.B. Expn.)
5.	55	Grinder No.6 (F.B. Expn.)
6.	100	Compressor No.3
7.	100	Compressor No.4
8.	110*	Compressor No.2
9.	110*	Ball mill grinder (No.7, F.B. Expn.)

* only load test was conducted

Results

Based on the data collected during the no-load and load tests, the performance parameters, i.e.,operating load (as per cent of rated load), efficiency and power factor, were evaluated for six of the motors for which both load and no-load data was available. The results of the analysis and the inferences drawn thereby are summarized in Table 8. It may be noted that in the case of the 100-kW compressor motor (No.4), the no-load values have been assumed to be the same as that for compressor No.3 on which the no-load test was conducted. For some motors the stator resistance has been assumed since the resistance test could not be performed. However, all these assumptions are based on the performance of new motors, thereby resulting in slightly optimistic values of efficiency and operating load. The performance of motors under different load conditions has also been simulated and the results from this analysis are given in Fig. 1-3.

It can be seen from Table 8 that motors are operating at loads varying from about 6 per cent for the 55-kW grinder motor, to about 70 per cent for the 100-kW Compressor (No.3) motor. The performance values evaluated are for instantaneous loads and may not reflect the performance of the motor at full load (discussions with plant personnel indicate that the motors were running under normal operating conditions, and therefore, the values would

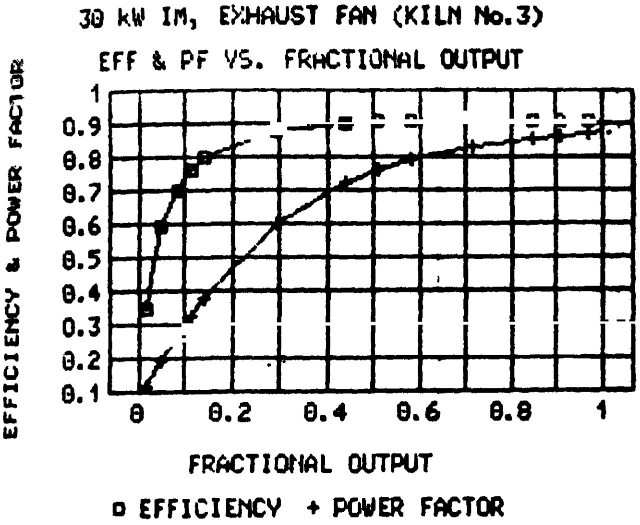

Figure 1

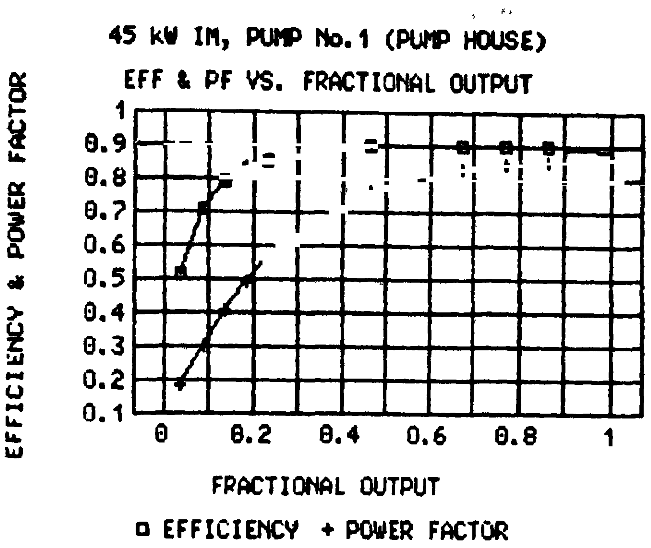

Figure 2

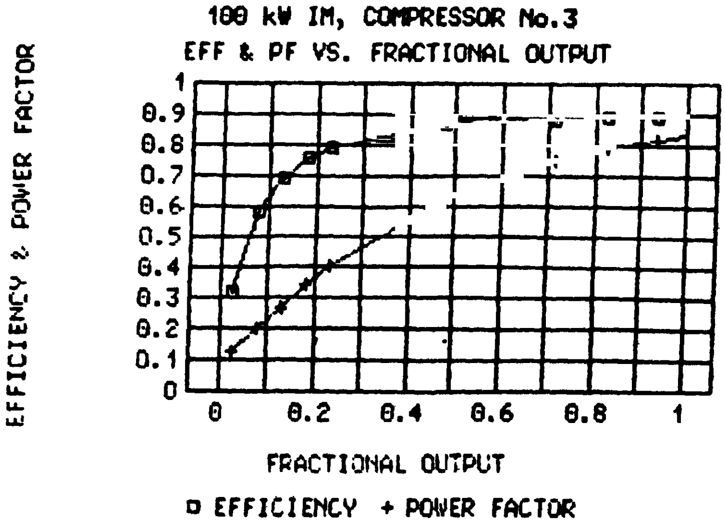

Figure 3

reflect the performance under operating conditions). The observations and recommendations based on measurements and analysis are given below.

Table 8

Motor Performance Characteristics

Motor Rating (kW)	Output Loading (%)	Efficiency (%)	Power Factor	Manufacturer's data at same load (approx.)	
				eff.(%)	p.f.
30	57.3	90.0	0.78	89.0	0.78-0.8
45	67.5	90.0	0.84	90.0	0.8-0.82
55	8.5	70.3	0.29	-	-
55	6.4	66.8	0.35	-	-
100	70.1	88.6	0.73	91.0	0.75
100	54.1	88.9	0.79	89.5	0.77

Observation	Recommendation
1) 30-kW exhaust fan motor (Kiln No.3)	
The motor is operating at a load of 57 per cent of rated value. The performance values are in conformance with manufacturers' data.	i) Due to the high operating efficiency, it would not be economical to replace the motor with a high-efficiency motor. Therefore, no change is recommended. However, it is recommended that tests be carried out on tunnel kiln exhaust fan motors to determine if these motors could be replaced with energy-efficient motors. Significant savings could be achieved, depending upon the present operating efficiency, since these motors operate for long periods of time.
2) 45-kW pump motor (No.1)	
The motor is operating at a load of nearly 68 per cent of rated load. The performance values are in	Due to the high operating efficiency of the motor, it would not be economical to replace it with an energy-efficient motor.

conformance with manufacturers' data.	No change is recommended.
3) 55-kW grinder motor (Nos. 3 & 6, F.B. Expn.)	
The motors are operating at practically no-load conditions. It was indicated by the operator that the grinders were loaded to normal levels of operation.	The possibility of fully loading the grinder should be studied. With this it would be possible to optimally load the motor and operate at higher efficiency. It would also reduce the hours of operation resulting in considerable savings. It was indicated by plant personnel that a hooter alarm would be installed if the level of loading were too low. Presently double cage rotor motors are being used. It is recommended that the load characteristics over a period of time be studied in detail to determine the rating of motor required. (The motor rating need not match the maximum load requirement if the maximum load occurs only for a short period of time over the total time cycle). Since considerable savings could be achieved, the possibility of using slip-ring or special motors of low rating, but designed for high starting torque, should be considered.
4) 100-kW Compressor No.3	
The motor is operating at a load of about 70 per cent of the rated value. The efficiency is slightly lower than that for a new motor.	Though some savings could be achieved by replacing the motor with a new motor, it would not be an economically attractive proposition. The motor could be replaced with an energy-efficient motor which would operate at an efficiency of 94 per cent and at a power factor of 0.85. This would result in annual savings* of about Rs. 28,260. The payback period would be about 3.7 years. (A 100-kW energy-efficient motor would not be readily available of the shelf and would have to be specially ordered).

5) 100-kW Compressor motor No.4

The motor is operating at a load of about 54 per cent of rated load. The performance values are in conformance with manufacturers' data.

Though some savings could be achieved by replacing the motor with a new motor, it would not be an economically attractive proposition.

The motor could be replaced with an energy-efficient motor which would operate at an efficiency of 94 per cent and at a power factor of 0.80. This would result in annual savings* of about Rs. 14,600. The payback period would be about 7.2 years. (A 100-kW energy-efficient motor would not be readily available and would have to be specially ordered).

6) 100-kW Compressor motors (3 & 2)

The currents in the supply phases are unbalanced, i.e., 156.1 A and 134.5 A for motor No.3, and 140.6 A and 124.5 A for motor No.4, in the R & Y phases respectively.

The magnitude of unbalance is quite high. Unbalanced currents would give rise to severe harmonics which would cause opposing torques. This results in an increase in the power input. It is recommended that balanced supply be ensured to the motors.

Compressor No.4 is drawing much less power than compressors No. 2 & 3 though the load on the compressors is likely to be the same. It is recommended that the reason for this be investigated.

In addition to these tests, measurements on load were also made on five other motors. These included a 11-kW recirculation pump motor, one 110-kW compressor motor and one 110-kW ball mill motor.

In the absence of no-load test data, the performance values for these motors could not be evaluated. However, the following observations are made based on the values measured.

Observation	Recommendation
11-kW Cooling water recirculation pump No.1	
The motor is operating at a load of about 65 per cent of the rated load.	Since the pump operates intermittently, it may not be economical to replace the motor with an energy-efficient motor.
110-kW Compressor motor No.2	
The motor is operating at a load of about 70 per cent of the rated load.	Based on the operating efficiency, which could be evaluated by testing the motor under load and no-load conditions, the economic feasibility of replacing the motor with an energy-efficient motor could be evaluated.
110-kW Ball mill grinder (No.7, F.B. Expn.)	
The motor is operating at about 36 per cent of rated load.	The possibility of fully loading the ball mill should be studied. With this it would be possible to optimally load the motor and operate at higher efficiency. It would also reduce the hours of operation resulting in considerable savings. It was indicated by plant personnel that a hooter alarm would be installed if the level of loading were too low. It may be noted that in the case of ball mills, about 90 per cent of the running power demand is required for idle motion, and there is a linear relationship between the power demand and the mass flow rate. The smallest specific power demand is realized by running the mills at the maximum load, and the smallest specific energy consumption by the maximum utilization of the time available. Presently double cage rotor motors are being used. It is recommended that the load characteristics over a period of time be studied in detail to determine the rating of motor required. (The motor rating need not match the maximum load requirement if the maximum load occurs only for

a short period of time over the total time cycle). Since considerable savings could be achieved, the possibility of using slip-ring or special motors of low rating, but designed for high starting torque, should be considered.

*** Assumptions:**

1) Hours of operation - Compressors - 2/3rd of the time

2) Monetary savings have been computed based on a tariff of Rs. 0.60/kWh. and a demand charge of Rs. 50/kVA.

3) Salvage value of 25 % considered for the old motor.

Use of Flat Belts. It is recommended that V-belts be replaced with flat-belt drive systems, wherever feasible. Use of flat belts would result in savings of about 8-12 per cent, due to their higher transmission efficiency.

Observation	Recommendation
100-kW Compressor motor (No.3) using flat-belts (consuming 79.1 kW of power).	Replacement with a flat-belt drive system would result in annual savings of about Rs. 24,500. The investment required would be low if the pulleys being used presently were machined to use flat belts.

Since significant energy and monetary savings are indicated, it is recommended that the option of using flat belt drive systems be studied for all drive systems which are currently using V-belts.

Use of motor controllers. It was indicated by plant personnel that soft-start motor controllers were installed at some motors. It is recommended that the possibility of installing such controls for all grinder and mill motors be studied. Significant savings could be achieved since these controllers, in addition to providing soft-start facility, would also reduce the supply voltage at low-load conditions, thereby improving the power factor. Since the grinders and ball mills frequently operate at very low loads, it should be economically attractive to install these controllers.

Power-Factor Correction. It was indicated by the records maintained at the main sub-station that the average power factor for the entire plant is maintained at over 0.95. Capacitor banks have been installed at sub-stations within the plant. Capacitors are also installed at the pump house.

Location. Since the plant is spread over a wide area, it is advisable to connect capacitors across the terminals of all motors of rating above about 11 kW. However, the economics of such a proposal can be evaluated only based on a comprehensive study. It is recommended that the economics of installing capacitors at each of the grinder and mill motors be evaluated since these motors operate at very poor load factors and consequently, at very poor power factor.

Sizing. When installing capacitors at individual motor terminals, care should be taken to ensure that capacitors are properly sized. It is recommended that rating of capacitor required be determined based on actual measurements. The capacitor rating should not exceed about 90 per cent of the no-load kVAR of the motor.

Energy Savings. With proper power factor correction provided at the right locations, significant savings could be achieved not only due to reduction in line losses, but also due to improved voltage regulation leading to an increase in the overall system efficiency.

Lighting

Measurements and Data Collection

In order to determine the quality of lighting provided, the level of illumination was measured at several sections of the plant. Other performance indicators such as type of lamp used, type of luminaire, mounting height, physical condition of lamps and luminaires, and use of daylighting were also noted.

The illumination levels measured at different locations and the recommended level of lighting in these areas are given in Table 9.

Table 9

Measured and Recommended Light Levels

Area	Lux (Measured)	Lux (BIS recommended value)
Administrative Block		
Main hall		
raw materials dept.	380	300
purchase dept.	250	300
typist's desk	150	300
office room	220	300

Table 9 (Contd.)

Measured and Recommended Light Levels

Area	Lux (Measured)	Lux (BIS recommended value)
Drafting hall		
at different tables	330*	
	390	
	190	450-500
	320	
	520	
Computer centre		
different locations	350	
	400	300
	190	
office cabin	240	
Basic plant		
Silica		
horn 1250 press	80 (daytime)	
	160 (nighttime)	
press 2 (630 T)	50	150-200
FSP 16	90 (near operator)	
	260 (away from oper.)	
FSP 10	4	
Hand moulding area	80 (near operator)	150-200
	450 (below lamp)	
Fire brick pressing	115	150-200
Bucher press	75	150-200
Basic office	120	250-300

Note: BIS - Bureau of Indian Standards
* daylighting + artificial lighting

The illumination levels required for manufacturing areas depend upon the difficulty of the task to be performed. It can be seen from Table 9 that the light levels inside the plant during daytime are lower than those specified by BIS standards. However, illumination levels were felt to be adequate by plant personnel.

The total lighting load of the plant is about 300-kW and lighting in the plant is mainly provided by 250-W high-pressure sodium vapour lamps. Some high-pressure mercury vapour lamps have also been provided. Office areas are illuminated using fluorescent lamps.

Daylighting has been effectively used in some areas of the plant and lamps are not normally used during daytime in some of these areas.

Recommendations for improving light levels in some areas and reducing electricity consumption in the lighting system are given below.

Observations	Recommendations
Basic plant	
Fluorescent lamps used at the sub-station	Relocate lamps so that they are not situated above the bus-bars. Presently, most of the light from these fixtures is blocked. Disconnecting these lamps may not significantly reduce the illumination level. It is also recommended that these lamps be provided with reflectors.
Task lamps have been provided at the manual presses.	Relocate the lamps closer to the work plane, so that they provide more illumination.
Basic office	
Eight fixtures with 4 lamps of 20-W in each has been provided.	With the use of mirror-optic luminaires and proper distribution of fixtures, greater illumination, than at present, can be provided. Four mirror-optic luminaires with twin 36-W fluorescent lamps would be sufficient. This would reduce the installed wattage by about 46 per cent, resulting in annual savings of about 3,500 kWh from this small office space.
D.G. room	
This area has good daylighting, but lamps are left on.	Avoid use of lamps during daytime
Filtering area	
In this area, high-pressure mercury vapour lamps have been used in addition to sodium vapour lamps.	Avoid the use of mercury vapour lamps. Daylighting in this area can be increased by using translucent FRP sheets, which could be provided on the sides.

	This would obviate the need to use lamps during daytime. Since 4 no. of 400-W H.P.M.V. lamps and 2 no. of 250-W H.P.S.V. lamps are presently being used, significant savings would also be realized.
· Kiln area	
H.P.S.V lamps are used. In addition, fluorescent lamps are provided along the sides of the kiln.	The fluorescent lamps are not required since the sodium vapour lamps provide sufficient illumination. It is also recommended that the central portion of the ceiling be painted white in colour and some FRP sheets provided. This would considerably increase daylighting and may obviate the need to use lamps during daytime.
Silica brick store yard	
This area has very good daylighting. All lamps are switched on.	Switching off all lamps did not significantly reduce the illumination level. However, the operator felt that lights are required to check for cracks during inspection. It is recommended that checking be restricted to certain area where lamps could be provided, and other lamps could be switched off. Alternatively, selective switching could be provided so that alternate lamps could be switched off.
Friction screen presses	
Task lighting is provided. Lamps are left on during breaks.	The task lights could be connected such that they are switched off along with the machines. This would avoid waste.
Compressor room	
4 no. of 250-W H.P.S.V. lamps are used.	FRP sheets could be provided along the sides to provide daylighting. It might obviate the need to use lamps during daytime, resulting in savings in electricity.

Speciality product plant

This area has adequate daylighting, but lamps are used along one side.

It should be ensured that these lamps are not used during daytime. Alternatively, alternate lamps could be switched off during daytime.

General plant area

In the Basic Plant, provision for daylighting has been made only in some areas. The area near the presses has a lot of dust and therefore requires greater illumination.

Additional FRP sheets could be provided at many locations to improve daylighting and reduce the lighting load during daytime. The provision of blue FRP sheets should be avoided.

The illumination in the passages is much higher than in work areas. It is recommended that instead of providing parallel lines of lamps, a zig-zag arrangement of single lamps be provided. This would considerably reduce the lighting load. Alternatively, the lamp wattage could be reduced in alternate fixtures.

Administrative Building & Office areas

Fixtures with four 20-W fluorescent lamps are are used in some areas.

It is recommended that the use of these fixtures be avoided since these fixtures are very inefficient. Over a period of time the translucent plastic cover yellows with the impingement of ultraviolet rays thereby further reducing the light output.

The use of efficient mirror-optic luminaires should be considered for all office areas. With proper designing of the lighting distribution system, the number of fixtures and the electricity consumed in lighting could be reduced.

In the administrative building, the cabins may be provided with venetian blinds instead of drapes to effectively use daylighting.

	It was observed that in most cabins, drapes had been pulled to avoid glare and lamps were switched on. Alternatively, provision of sun films on these windows could be considered.
Outdoor areas	
H.P.S.V. & H.P.M.V. lamps are being used for street lighting	It is recommended that the use of low pressure sodium vapour lamps of 135-W be considered. These are amongst the most efficient lamps manufactured - a 135-W low pressure sodium vapour lamp has an efficacy (ratio of lumens to watt of about 160 compared to 118 for a 400-W H.P.S.V. lamp or 58 for a 400-W H.P.M.V. lamp (excludes ballast wattage). Therefore, significant savings could be achieved with the use of these lamps.

Beblec India Private Limited manufactures a device known as the Beblec P-20 which basically introduces an impedance in the lighting circuit,thereby reducing the current drawn by the light source. This reduces the power dissipated by the lamp slightly, leading to savings in electricity. The reduction in the lumen output, however, is not significant. These devices are available in capacities ranging from 1.5-25 kVA, for both single-phase and three-phase applications. The device can be used with both fluorescent lamps and high intensity discharge lamps. The manufacturer claims savings of up to 20 per cent in the lighting electricity consumption. This has been used in many textile industries which have reported satisfactory results. Since significant savings are indicated, it is recommended that this device be tried out with a few lamp circuits in the plant and in office areas and the savings monitored. Depending on the results, its use could be extended to all lighting circuits.

Major savings in lighting electricity consumption could be effected by inculcating a consciousness among the workers and staff members. It was observed, and also pointed out by plant personnel, that there was less waste in some areas as compared to some other areas. This was mainly due to the some departmental heads being more conscious than others. It is therefore recommended that periodic training and awareness programmes be held, and suitable signboards (see Appendix V) be put up to emphasize the need for energy conservation.

It is important to realize that though the electricity consumed in the lighting system might form only a fraction of the total electricity consumption, proper lighting contributes appreciably to improved work atmosphere and increased productivity.

INSTRUMENTATION

The energy audit team recommends the use of both static and portable instruments at various locations in the plant to measure critical energy related parameters. A list of instruments along with manufacturers' and dealers' addresses are provided in Appendix I.

ENERGY MANAGEMENT STRUCTURE

Top management's involvement is essential for a successful energy management programme. This was evident at the Tata Refractories Limited, where Mr. Md. Fasihuddin, Resident Director, Mr. T.P. Chakraborty, Mr. T.K. Ghose and other managerial staff showed keen interest in the preliminary energy audit, its scope, methodology, results and recommendations.

Since this is a large-sized unit (by energy consumption) an energy manager* who would perform the energy management functions full-time should be appointed. He should be a member of the existing energy conservation committee (steering committee) consisting of representatives from Production, Projects and Maintenance, and R&D Divisions, Administration and Accounts. Further, the energy manager should be assisted by representatives from operating and maintenance departments. The operating department's representatives would in turn be assisted by operating shift representatives. Figure 4 provides a simplified view of the proposed energy management organization for Tata Refractories Ltd.

The energy manager would be responsible for regular monitoring and reporting of energy consumption, and for increasing the energy efficiency of the plant. Moreover, he would be responsible for maintaining the savings already achieved, which is rather a difficult task. He would also be responsible for motivating and training people at all levels in the plant towards higher energy efficiency.

Appendix V provides a brief outline of how to initiate and manage an energy management programme at TRL.

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* Initially, a full-time energy coordinator may be appointed, who could be promoted as an energy manager after a few years.

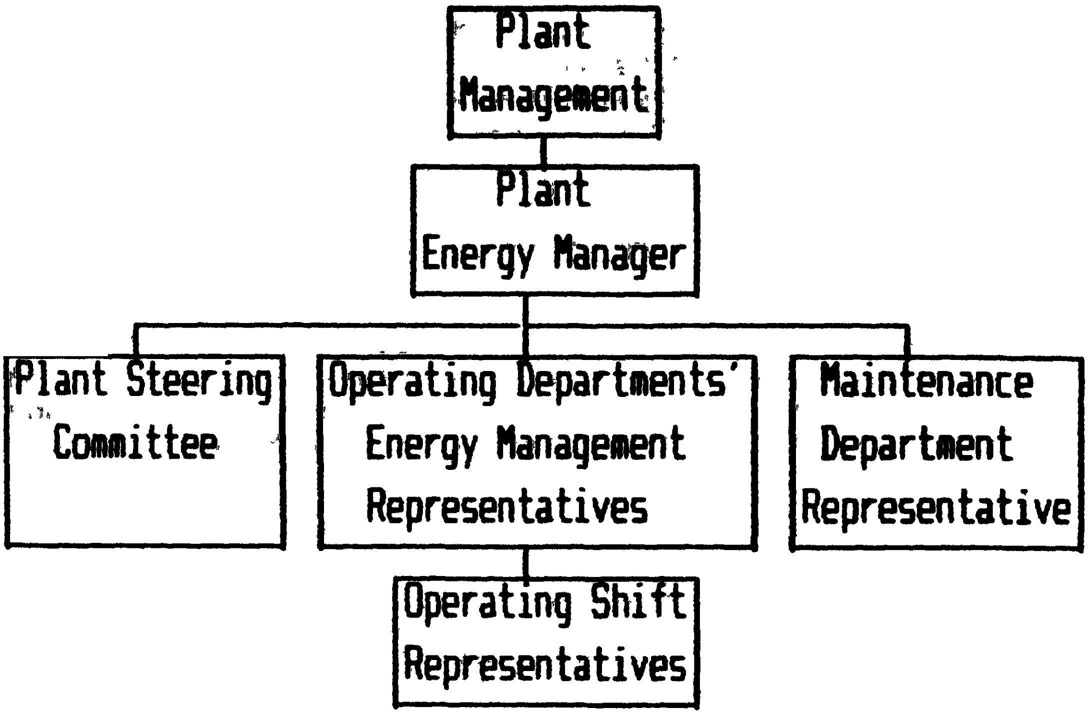
Plant Management
Plant Energy Manager
Plant Steering Committee
Operating Departments' Energy Management Representatives
Maintenance Department Representative
Operating Shift Representatives

Fig.4: Plant Energy Management Organization

CONCLUSIONS

The preliminary energy audit conducted by the Tata Energy Research Institute at the Tata Refractories Limited's plant at Belpahar, Orissa revealed that there is a significant potential for savings in both thermal and electrical energy use. The thermal energy savings (fuels) are estimated to be approximately 25-30 per cent of the present energy consumption. The major areas are tunnel kilns, driers and producer gas plants and their associated systems. Estimated electrical energy savings are in the range of 12-15 per cent of the present consumption. This could be achieved mainly through proper sizing of motors, use of energy-efficient motors, replacement of V-belt drives with flat belt drives, use of motor controllers, pf correction at load centres and changes to the lighting systems.

To achieve the full potential for energy savings, it is important to get organized to manage energy consumption in the plant. This requires appointing an energy manager/coordinator and strengthening the activities of the Committee on Energy Conservation which was formed recently.

Top management's commitment, involvement and visibility, and a properly organized energy management structure are vital to ensure a successful and sustainable energy management programme.

APPENDIX I

CONTACT ADDRESSES

Tunnel Kiln Cars - Reduction of Thermal Mass

a. Director
Central Glass and Ceramic Research Institute
P.O. Jadavpur University
Calcutta - 700 032

b. Burton-Werke K.-F. Hensick GmbH+Co.
P.O. Box 120
D-4520, Melle 5/Buer
West Germany

Portable Combustion Optimizer (PCO) and Fuel Efficiency Monitor (F.E.M.) (Portable)

Dealer:
Combustion Analysers
170 Kailash Hills
First Floor
New Delhi 110 065

Contact: Mr. Adarsh Kapur

Digital Temperature Indicator (Portable)

Manufacturer:
Siemssen & Co.
Mittelweg 136
P.O. Box 1849
D2000, Hamburg 13
West Germany

Dealer:
Toshniwal Sensors Pvt. Ltd.
E 19-20 Industrial Area
Makharpura, Ajmer 305 002
Rajasthan

Power Multimeter (Portable)

Manufacturer:
Esterline Angus Instrument Corporation
P.O. Box 24000
Indianapolis
Indiana 46224
U.S.A.

Dealer:
Motwane Pvt. Ltd.
Y-22 Okhla Industrial Area
Phase II
New Delhi 110 020

5. **Oil Flow Meters**

Dealer:
S.S. Engineering Industries
H-35 South Extension, Part I
New Delhi 110 049
(Markets flow meters made by
Kent Meters Limited, U.K.)

Manufacturer:
Digital Electronics Limited
74/11 'C' Cross Road
Marol MIDC, Andheri (East)
Bombay 400 093

6. **Energy Saving Device for Lighting**

Manufacturer:
Beblec (India) Pvt. Ltd.
126 Sipcot Complex
Hosur 635 126
Tamil Nadu

Contact: Mr. Arif Vizirally
Executive Director

7. **Electronic Chokes for Fluorescent Lamps**

Manufacturers:
a. Digitron Electronics India Limited
472 Sector 15, Industrial Area
Phase II Road
Panchkula 134 109
Haryana

b. Apar Limited
Lighting Division
Maker Chambers No. III, 1st Floor
Jamnalal Bajaj Road
Nariman Point
Bombay 400 021

Contact: Mr. Vijay Kirpal
General Manager (Marketing)
Specialty Lamps & Luminaires

8. **Heat Pipe Heat Exhcnagers**

Manufacturers:

a. Bry-Air (India) Pvt. Ltd.
20 Rajpur Road
Delhi 110 054

Contact: Mr. Deepak Pahwa
Managing Director

b. Thackersey hi-tech
Yadav-Patil Lane
Veer Savarkar Marg
Bombay 400 025

APPENDIX II

Hot Air Ducts and Driers

Heat Loss

Fan capacity (design) - 20000 cu. m/h*

Hot air temperature - $200^{\circ}C$

Ambient temperature - $30^{\circ}C$

Furnace oil cost (avg) - Rs. 4270/tonne

Assuming 15% heat loss from the system,

Annual energy loss $= 20000\ m^3/h \times 0.316\ \frac{kcal}{m^3.C} \times 170^{\circ}C$

$$8760\ h/a \times \left(\frac{1}{10^7}\right) t/kcal$$

$$(\times 0.15) \times Rs.\ 4270/t$$

= Rs. 603,000

The table below provides annual heat loss for various percentages of heat loss assumed, for ready reference.

Percentage heat loss	Annual heat loss in rupees (thousands)
10	402
15 (estimated)	603
20	804
30	1206
40	1608

The calculation method shown above could be repeated for any values of the parameters, and percentage heat loss.

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* The actual air flow rate in any duct could be measured by using a pilot tube.

Appendix III
Diesel Generator Sets
Operating Tips for Fuel and Lube Efficiency

1. Select proper fuel. If the injection system can tolerate more viscous fuels like LDO, furnace oil or other residual fuels like LSHS or HPS, go for higher viscosity fuels.

2. Ensure proper storage and handling of fuel. Dirt and contamination will make the fuel go off specification.

3. Load the DG set above 50 per cent for large D.G. sets, and above 60 per cent for small sets.

4. Ensure proper fuel injection, correct viscosity and temperature, timing, proper mechanical condition of components, and prevent lube contamination.

5. Select proper lubricant. Monitor lubricant condition through regular sampling and analysis of used oil. Ensure proper lubricant cooling and consumption. **(Thicker oil cause 2 per cent excess fuel consumption).**

6. Externally clean the air filters regularly, to ensure proper filteration and cleanliness of intake air.

7. Avoid leakages of fuel oil and lube oil, even though they may be of minor nature. They are a major cause for higher fuel and lube consumption.

8. Normally, engine oils of SAE 40 grades are used in D.G. sets, unless otherwise recommended by the manufacturers. Use of multigrade and higher performance level oils with high detergency, alkalinity reserve and antiwear properties help in both lube and fuel conservation in addition to improving engine mechanical efficiency.

9. Check compression pressure regularly if provision exists. Attend to stuck piston rings, leaky valves, clogged ports, excessive liner and ring wear, etc. promptly.

10. Insulate exhaust piping to reduce air temperature inside the generator room as the higher intake air temperature increases the specific fuel consumption and reduces engine output. **(Engine output reduces by about 5 per cent for 10 C rise in intake temperature)**

11. Avoid exhaust gas temperature above 450 C. High exhaust temperatures due to overload and restricted air supply, could lead to lower fuel efficiency as welll as fouling of turbo-chargers.

12. Avoid over lubrication to prevent deposits inside the engine and on the turbo-charger blades.

13. Maintain the cooling circuit system and clean heat exchangers regularly. Meet manufacturer's norms on cooling water temperature, back pressure, flow rate, quality etc.

14. Adopt preventive or preferably predictive maintenance programmes.

15. Attempt waste heat recovery, if technically and economically viable.

Appendix III (Contd.)

Diesel Generator Sets

Measures for Diesel Engine Lubrication Oil Conservation

1. Improve air filtration

2. Reduce fuel dilution by

   a. ensuring proper atomization
   b. having correct engine temperature
   c. having proper air-fuel ratio
   d. ensuring proper crankcase venting
   e. eliminating worn out rings and cylinder liners

3. Check insolubles build-up in oil by using proper air, oil and fuel filters.

4. Reduce oil loss by proper clearnace between valve stem and guide

5. Reduce oil loss past piston by

   a. reducing carbon deposits on top land
   b. avoiding bore polishing and glazing
   c. attending to ring wear

6. Provide by-pass purification system or remove insolubles by centrifuging

7. Use long drain oils with improved air and oil filters

8. Monitor TBN values more closely where high sulphur diesel is used.

9. Switch on to multigrade oils for oil as well as fuel economy

10. Check for leaks in the lubrication system and attend to them promptly

11. Change oil on condition basis and not on the thumb rule recommended by oil companies or engine builders. Field oil testing systems are readily available in the country

12. Oil never deteriorates. It goes off specs temporarily. The drained oil can be re-refined and brought to proper level by appropriate re-refining and reclamation techniques. For further details on refining, consult PCRA booklet titled 'How to Conserve Lubes' (through recycling). For any further information on this, please contact PCRA, New Delhi.

Note: Oil refers to engine lubricant and fuel refers to diesel oil.

* PCRA - Petroleum Conservation Research Association.

Appendix IV

Notes For Heat Loss Tables

1. Ambient temperature = 28.4°C

2. Net heat loss refers to recoverable heat.

   Net heat loss = Actual heat loss - Heat Loss at the minimum allowable temperature difference (assumed) between the hot surface and the ambient

3. Allowable temperature difference (T)

   For hot surfaces of tunnel kilns

   BTK (zone 21, 26, 29) and
   HTK (zone 16, 17, 18) : 40°C

   BTK (zone 16) : 10°C

   Air blower surface : 10°C

   Air duct : 5°C

4. Annual operational hours : 8760

5. Assumed thermal heating
   efficiency for furnace oil
   in furnaces : 0.7

6. F.O.: 10,000 kcal (=11.63 kWh) = Rs. 4.03

APPENDIX V

Initiating and Managing an Energy Management Programme

Once the energy management organization is established and lines of responsibilities defined, managing the programme begins. Planning is vital to implement a successful energy conservation programme.

An important consideration throughout the programme is the fact that people often tend to resist change. Failure to provide for overcoming this resistance will result in an ineffective programme. No matter how good the programme may be, if people do not accept or understand the reasons for the programme or are not willing to carry it out, the programme will fail. In other words, the programme must consider the interests and motivation of people who will implement it. A good programme starts where the company is now and carries people forward to an end result they can visualize.

One of the most successful means of motivating employees is through "awareness". Employees can be stimulated to support an energy management programme if they are informed of (1) the amount of energy they are using, (2) the costs involved, (3) the critical part that energy plays in the continued viability of the company, (4) the many ways they can save energy in their operation, and (5) the relationship between production rate and energy consumption.

Training, publicity and promotion are essential ingredients of a successful energy management programme. Adequate training for employees has to be one of energy manager's top priorities and certainly one of his responsibilities in directing and guiding others. In addition, training can act as a motivator. Publicity and promotion are an important arm of motivating employees to save energy.

Listed below are some suggestions for publicising and promoting an energy management programme.

1. Posters and pamphlets on energy conservation.

2. An agenda item on energy conservation is included at staff meetings.

3. Plant and department performance results on energy conservation are posted monthly by the plant energy manager and the unit representative.

4. Unit representative and several unit personnel conduct quarterly on-site reviews, a walk-through of the unit looking for energy-saving opportunities.

5. An Energy Awareness Day is set aside in the plant twice a year.

6. Quarterly meetings are held in the plant for all unit representatives.

7. A company energy management logo is developed and adopted.

A good point to remember when publicizing energy conservation is to use terms that employees can relate to in everyday life. Translating energy units (Btu, kcal, etc.) to monetary terms is a good method of communicating with the employees.

It is recommended that Tata Refractories Limited employ an artist to develop pictures for signboards, posters and stickers on themes related to energy conservation. Here are some suggestions on messages:

Stickers

1. "Turn off lights and fans when not required"

2. "Maintain your machine in top running condition - save energy"

3. "Close door; keep cool in" (for rooms with A.C.'s)

4. "Save electricity; do not let your machine run idle"

5. "If you are leaving (the room), have you turned off lights and fans ?"

6. "Save energy; turn off A.C. half an hour before you leave"

Posters/Signboards

1. "Save energy; help nation"

2. "Do you have any suggestion to save energy; please contact ...."

3. "Energy is expensive; use it wisely"

4. "Save energy; reduce pollution"

5. "Save energy; preserve ecology"

The above messages for stickers are primarily related to electrical energy; however, these can be modified to suit other forms of energy. As Tata Refractories uses fuels and electricity, it is important that these messages cover all energy forms. These messages and additional ones, if any, should also be translated into simple Hindi/Oriya to reach operators and others who may not be able to read English.